

Reporting Verification of BOP Shear Ram Capability

Requirements and Good Practices on Reporting Blowout Preventer (BOP) Shear Ram Capability for Outer Continental Shelf (OCS) Oil and Gas Operations

Energy Systems Division

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This report was prepared by Argonne National Laboratory (ANL) under contract to the Department of Energy (DOE) through an interagency agreement between the Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE) and the DOE. The opinions, findings, conclusions, and recommendations expressed in the report are those of the authors and they do not necessarily reflect the views or policies of BSEE.

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Enforcement

July 29, 2019

Contents

1.0	Introduction.....	1
2.0	Regulatory Requirements and Terminology Conventions of this Report.....	3
2.1	Important Regulatory BSR Shear Testing and Reporting Requirements	3
2.1.1	Relevant Requirements in Well Control Rule and Proposed Well Control Rule.....	3
2.1.2	Requirements from API Standard 53	5
2.1.3	Relevant Requirements from ANSI/API Specification 6A	6
2.1.4	Relevant Requirements from ANSI/API Specification 16A	7
2.1.5	Relevant Requirements from ANSI/API Specification 16c.....	7
2.1.6	Relevant Requirements from API Specification 16D	7
2.1.7	Relevant Requirements from ANSI/API Specification 17D	7
2.2	Interpretations, Good Practices, and Terminology	7
3.0	General Information.....	9
3.1	Rig Identification	9
3.2	Well(s).....	9
3.3	HPHT Conditions.....	9
4.0	Drilling Rig Equipment.....	10
4.1	Drilling Rig Shear Ram	10
4.2	Drilling Rig Shear Ram Support Systems	13
4.3	Anticipated Well Conditions Pertinent to Shear Ram	14
4.3.1	General Well Parameters	14
4.3.2	Maximum Anticipated Surface Pressure and Other Pressure Corrections ..	14
4.3.3	Maximum Anticipated Well Pressures and Temperatures.....	14
5.0	Shear Ram Testing Information.....	15
5.1	Testing Facility Details	15
5.2	BSR(s) Tested	16
5.3	Test Setup.....	16
5.4	Test Procedure/Protocol Followed and Acceptance Criteria	17
5.5	Test Specimen Selection	18
5.6	Shear Ram Inspection Information	18
5.6.1	Pretest Shear Ram Inspection Report	18
5.6.2	Post-Test Shear Ram Inspection Report	18
5.7	Test Results	18

5.8	Photographic and/or Video Records	20
5.8.1	Shear Results—Tubulars	20
5.8.2	Shear Ram Condition Tests	20
6.0	Engineering Analyses and Assessments	26
6.1	Theoretical Shear Calculations	26
6.2	Shear Ram Support Systems Capability Assessment	26
6.3	Certainties Assessment	27
6.3.1	Expected Variation in Test and Calculated Shear Pressures	27
6.3.2	Comparisons of Rig Versus Tested Equipment	27
6.4	HPHT Specific Requirements.....	28
7.0	Statement on Shear Ram and System Fitness for Service	29
7.1	Shear Ram.....	29
7.2	Support System	29
7.3	Caveats and Limitations.....	29
8.0	References for Shear Reporting.....	30
	Appendices.....	1
A:	Quality Assurance Program	A-1
	Testing Activities	A-1
	Engineering Analyses	A-1
B:	Personnel Qualification and Credentials.....	B-1
	Third-Party Professional and Engineering Qualifications/Registrations	B-1
	Other Pertinent Qualifications.....	B-1
C:	Miscellaneous Information	C-1
	Manufacturer’s Specifications.....	C-1
	Test Procedures	C-1
	Tubular and Wire Chemistry.....	C-1
	Tubular and Wire Physical Property Reports.....	C-1
	Pre- and Post-Test Inspection Reports	C-1
	Raw Shear Test Data or Recording Charts.....	C-1
D:	Cross Tabulation of Major Requirements to Paragraphs.....	C-1

List of Tables

1	BOP Shear Ram Configuration Data Sheet	10
2	Shear Test Specimen Data Sheet	12
3	Test Facility Information	15
4	Shear Test Summary Results	19
5	Attributes of Desirable Photographic Documentation	21
D-1	BSR Shearing Report Requirements, Topics, and Sections Addressing Those Topics.....	1

List of Figures

1	Example Photographs of Shear Ram Ready for Shear Testing	23
2	Example Photograph of Sheared Tubular Showing Shape Distortion.....	24
3	Example Pictures of Drill Pipe Shears and Shear Test Fixture Used	25

List of Acronyms

Acronym	Description
ANSI	American National Standards Institute
API	American Petroleum Institute
BOP	Blowout Preventer
BSEE	Bureau of Safety and Environmental Enforcement
BSR	Blind Shear Ram (of BOP)
HP	Horsepower
HPHT	High-Pressure High-Temperature
HRC	Hardness Rockwell C Scale
ID	Inside Diameter
ISO	International Standards Organization
MASP	Maximum Anticipated Surface Pressure
MAWHP	Maximum Allowable Wellhead Pressure
MESWP	Maximum Expected Wellbore Shear Pressure
NIST	National Institute for Science and Technology
OCS	Off Shore Continental Shelf (Gulf of Mexico)
OD	Outside Diameter
OEM	Original Equipment Manufacturer
P&ID	Piping and Instrumentation Diagram
POC	Point of Contact
POS	Point of Shear
PM	Preventive Maintenance
RWP	Recommended Working Pressure
RWT	Recommended Working Temperature
S/N	Serial Number
WCR	Well Control Rule

1.0 Introduction

The Bureau of Safety and Environmental Enforcement (BSEE) Well Control Rule (Subpart G)¹ became effective on July 28, 2016. This rule is part of the BSEE regulations pertaining to well control equipment used for oil and gas operations on the U.S. Outer Continental Shelf (OCS). More recently BSEE issue a proposed rule to amend portions of the 2016 well control rule. This proposed rule (now implemented) appeared in the Federal Register on May 18, 2018. This report was prepared late in the public comment period for the current rule and intended is a sample of desirable documentation of blind shear ram shear testing and associated regulatory requirements either in place or anticipated at the time of preparation.

In accordance with this original rule and the proposed revisions, BSEE requests specific information regarding the capabilities of blind shear rams (BSR) in the Blowout Preventer (BOP). This information is required prior to beginning any operation involving the use of any BOP. More specifically, Title 30 CFR 250.732(b) of these regulations requires documentation of shear testing demonstrating the shearing and sealing capabilities of the BOP BSR. Such documentation is consistent with and complementary to other documentation verifying the designs of individual well control components and the overall BOP system. Verification demonstrates performance and reliability of the equipment based on a testing process that is repeatable and reproducible.²

This document, an annotated outline of verification documentation, arises from the combination of regulations and good practices concerning how to report BOP shear ram tests and third-party verification of BSR capability to support BSEE's regulatory role. The following summarizes suggested content of a capabilities and verification document:

- Description of the testing facility, test equipment, test equipment calibration, and certification;
- Design and operational details about the specific shear ram(s) tested;
- Technical details on any tubulars and wirelines sheared during capability testing;
- Testing procedures and methods used;
- Test results and acceptance criteria for the shearing and sealing tests;
- Design and operational details about the shear ram(s) to be used for well control operations on the actual rig;

¹ Appearing in BSEE regulations at Title 30, Chapter II, Subchapter B, Part 250-Oil and Gas and Sulfur Operations in the Outer Continental Shelf, 250.700 (Subpart G) "Well Operations and Equipment," (Accessed October 2018).

² See Title 30 CFR §250.732 (b)(1)(ii), "... use of test protocols and analysis that represent recognized engineering practices for ensuring the repeatability and reproducibility of the tests, and that the testing was performed by a facility that meets generally accepted quality assurance standards."

- Technical details (physical, chemical and mechanical attributes) on all tubulars and wirelines on the actual rig that might need to be shared;
- Engineering calculations and analyses related to the testing, adjustments for field versus test conditions, and impacts of technical differences between the tested and planned hardware; and
- Description and documentation of quality assurance program(s) and processes applied to the verification process.

Per the regulations, a competent third-party is to certify that test data demonstrates shearing capability at water depth. For high-pressure, high-temperature (HPHT) well conditions, there are additional documentation requirements. These requirements pertain to the BOP system's overall performance at temperature and adherence to recognized engineering and manufacturing practices including associated quality assurance.

This document is a format and organization for the presentation of appropriate technical information on BSR testing and expected performance. The content is intended to be consistent with regulatory language about testing and analysis repeatability and reproducibility and the format is one approach to capture topics/content deemed appropriate as good reporting practice or interpretation of regulatory requirements. For reference, important regulatory requirements for shear ram testing appear in Section 0 of this report. Sections 3.0 through 7.0 and Appendices A through C present content and explanations about a complete BSR test and analysis report. Appendix D is a cross tabulation showing where the majority of information appears in the report for the various regulatory requirements. The format is intended to be adaptable to a wide range of situations including where the tested BSR is not identical to the rig's shear ram and/or the sheared tubulars are different from those to be used for the planned well(s).

2.0 Regulatory Requirements and Terminology Conventions of this Report

This section lists key regulatory requirements for BOP BSR testing and analysis and explains terminology used in the balance of this document to distinguish between absolute requirements and good practices or suggestions/recommendations. These applicable regulatory requirements [Well Control Rule (WCR)] appear in Subpart G-Well Operations and Equipment. Documents, industry standards and specifications, incorporated in the regulations by reference³ (which establishes edition) appearing at §250.198 of the same part. The proposed (and now adopted) WCR is: “Oil and Gas and Sulfur Operations in the Outer Continental Shelf-Blowout Prevention Systems and Well Control Revisions,” found in the Federal Register.⁴

2.1 Important Regulatory BSR Shear Testing and Reporting Requirements

2.1.1 Relevant Requirements in Well Control Rule and Proposed Well Control Rule

Regulatory requirements applicable to BSR testing from Title 30 CFR250.700 (Subpart G) in the order of appearance are (actual text shown in quotes with exceptions noted to indicate the anticipated impact of the proposed WCR):

- 1) Meet (BSR) “The BOP requirements of API Standard 53⁵ (incorporated by reference in 30 CFR §250.198) and the requirements of §250.733 through 250.739. If there is a conflict between API Standard 53, and the requirements of this subpart, you must follow the requirements of this subpart.” [§250.730 (1)]
- 2) Meet... “Those provisions of the following industry standards (all incorporated by reference in §250.198) that apply to BOP systems:
 - a) (i) ANSI/API Spec. 6A
 - b) (ii) ANSI/API Spec. 16A⁶;

³ ANSI/API Specification 6A, “Specification for Wellhead and Christmas Tree Equipment,” 19th edition, Errata 1-5 & Addendum 1-4, December 2008, originally Effective February 1, 2005.

⁴ Proposed Rule by the Safety and Environmental Enforcement Bureau, “Oil and Gas and Sulfur Operations in the Outer Continental Shelf-Blowout Prevention Systems and Well Control Revisions,” Federal Register pages 22128-22162, Cited at 83FR 22128, 30 CFR250, Docket ID BSEE-2018-0002-189E1700D2 ET1SF0000.PSB000 EEEE500000, May 11, 2018.

⁵ API Standard 53, “Blowout Prevention Equipment Systems for Drilling Wells,” 4th edition.

⁶ ANSI/API Specification 16A [ISO 13533:2001 (modified), [Petroleum and natural gas industries-Drilling and production equipment-Drill-Through equipment]. “Specification for Drill-through Equipment,” Third edition including API Monogram Annex as part of US national adoption and Errata/supplement (November 2014), American Petroleum Institute, June 2004, Reaffirmed August 2010, Reaffirmed August 2016.

- c) (iii) ANSI/API Spec. 16C⁷;
 - d) (iv) API Spec. 16D⁸; and
 - e) (v) ANSI/API Spec. 17D⁹. [§250.730 (2) Note also slight differences in the reference titles here and those appearing on the actual document as provided in the footnotes]
- 3) Provide independent third-party — “Verification that (1) Test data demonstrate the shear ram(s) will shear the drill pipe at the water depth as required in §250.732” [§250.731 (1)];
- 4) Conduct shear testing that
- a) “(i) Demonstrates that the BOP will shear the drill pipe and any electric-, wire-, and slick-line to be used in the well, no later than April 30, 2018;
 - b) (ii) Demonstrates the use of test protocols and analysis that represent recognized engineering practices for ensuring the repeatability and reproducibility of the tests, and that the testing was performed by a facility that meets generally accepted quality assurance standards;
 - c) (iii) Provides a reasonable representation of field applications, taking into consideration the physical and mechanical properties of the drill pipe;
 - d) (Note-iv omitted since testing at edge of blade not likely to be required based on proposed WCR)
 - e) (v) Demonstrates the shearing capacity of the BOP equipment to the physical and mechanical properties of the drill pipe; and
 - f) (vi) Includes relevant testing results.” [§250.732 (b)(1)]
- 5) Conduct pressure integrity testing that
- a) “(i) Shows that testing is conducted immediately after the shearing tests;

⁷ API Specification 16C (Spec 16C), “Specification for Choke and Kill Systems,” 1st edition, American Petroleum Institute, January 29, 1993, Reaffirmed 2001, Effective January 29, 1993.

⁸ API Specification 16D (Spec 16D), “Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment,” 2nd edition, American Petroleum Institute, July 2004, Effective January 2005.

⁹ API Specification 17D/ISO 13628-4, “Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment” 2nd Edition with Errata 1 dated September 2011, Errata 2 dated January 2012, Errata 3 dated June 2013, Errata 4 dated July 2013, Errata 5 dated October 2013, Errata 6 dated August 2015, Addendum 1 dated September 2015, and Errata 7 dated October 2015, American Petroleum Institute, May, 2011 [effective February 1, 2013 [for Valve and Actuator Design Validation (Test Requirements) Only and November 1, 2011 for All Other Requirements].

- b) (ii) Demonstrates that the equipment will seal at the rated working pressures (RWP) of the BOP for 30 minutes; (Note: Proposed WCR: BSEE proposes to revise this to 5 minutes)
 - c) (iii) Includes all relevant test results.” [§250.732 (b)(2)]
- 6) Prepare calculations “Include shearing and sealing pressures for all pipe to be used in the well including corrections for MASP¹⁰.” [§250.732 (b)(3)].
- 7) For the HPHT environment provide:
 - a) “(3) Verification that the BOP equipment will perform as designed in the temperature, pressure, and environment that will be encountered”
 - b) “(4) Verification that the fabrication, manufacture, and assembly of individual components and the overall system uses recognized engineering practices and quality control and assurance mechanisms” including “For the quality control and assurance mechanisms, complete material and quality controls over all contractors, subcontractors, distributors, and suppliers at every stage in the fabrication, manufacture, and assembly process.” [§250.732 (b)(3) &(4)]
- 8) For surface and subsea BOPs: BSRs must be capable of shearing at any point along the tubular body of any drill pipe (excluding tool joints, bottom-hole tools, and bottom hole assemblies that include heavy-weight pipe or collars), work string, tubing.). [Paraphrased from §250.733 (1) and §250.734 (1)].

In this document these are all referred to as “must” level requirements. In the regulations, these are responses to a question given in each paragraph of Section §250.700. The applicant is to provide the information even though the actual performer may be another party such as the third-party verifier.

2.1.2 Requirements from API Standard 53

As stated in paragraph 2.1.1 BOP related requirements in API Standard 53 are applicable to BSR shear testing. Key applicant requirement topics associated with general BOP testing and/or BOP shear testing from the standard are:

- 1) Define maximum expected wellbore shear pressure (MEWSP) as “The expected operating pressure for a given hole section, a specific shear pressure requirement, specific operating piston design, and material specification, to shear drill pipe or tubing at the MASP (surface), MAWHP (subsea), or other pressure limiting value.”¹¹ [API Standard 53 Section 3.1.51],

¹⁰ MASP: Maximum Anticipated Surface Pressure

¹¹ MAWHP: Maximum Anticipated Well Head Pressure

- 2) Establish that as part of maintenance and testing “visual inspection should be performed, in accordance with equipment owner’s preventive maintenance (PM) program.” [API Standard 53 Section 6.5.2.1.2 for surface BOPs and Section 7.6.2.1.2 for subsea BOPs],
- 3) “Test pressure measurement devices (including analog gauges) shall be calibrated annually in accordance with OEM procedures”¹² [API Standard 53 Section 6.5.3.6.4],
- 4) Test pressure measurement device “Calibrations shall be traceable to a recognized national standard (NIST and ANSI).”¹³ [API Standard 53 Section 6.5.3.6.5],
- 5) “Prior to testing each ram BOP, the secondary rod seals (emergency pack-off assemblies) shall be checked to ensure the seals have not been energized. Should the ram shaft seal leak during the test, the seal shall be repaired rather than energizing the secondary packing.” [API Standard 53 Section 6.5.4.8 for surface BOPs only],
- 6) Documentation to demonstrate understanding of the “...effects of increasing wellbore pressure and its impact on the capability of shearing the drill pipe with a closed annular preventer....” [API Standard 53 Section 6.5.10.7.2],
- 7) “Due to the variations in pipe properties and corresponding shear pressures, the maximum expected pressure for shearing pipe should be less than 90 percent of the maximum operating pressure. An additional risk assessment should be performed if the shear pressure is higher than 90 percent of the maximum operating pressure.” [API Standard 53 Section 6.5.10.7.5], and
- 8) “The capability of the shear ram and ram operator shall be verified with the manufacturer for the planned drill pipe. The shear ram preventer design and differences among drill pipe manufacturers can require higher closing pressures for shear operations.” [API Standard 53 section 7.6.6.6 for subsea BOPs and similar for surface BOPs at Section 6.5.4.7].

The referenced standard allows for shearing capability to be determined from calculations or actual testing. However, the WCR (and proposed WCR) requires actual testing. In the WCR verification can be provided by a competent provider while API Standard 53 requires verification with the manufacturer (Section 6.5.4.7 for surface BOPs and Section 7.6.6.6 for Subsea stack equipment).

2.1.3 Relevant Requirements from ANSI/API Specification 6A

There do not appear to be any requirements in ANSI/API Specification 6A pertaining to BSR capability testing.

¹² OEM: Original Equipment Manufacturer

¹³ NIST: National Institute for Science and Technology, ANSI: American National Standards Institute

2.1.4 Relevant Requirements from ANSI/API Specification 16A

There are BSR testing requirements at section 5.7.2.4 pertaining to design verification. These are minimum shear pipe diameter, weight, and grades for given BOP size as shown in Table 18 of the specification. From paragraph 8.5.8.7.4 of the specification, “Each preventer equipped with blind-shear rams shall be subjected to a shearing test.” The paragraph continues: “These tests shall be performed without tension in the pipe and with zero wellbore pressure. Shearing and sealing shall be achieved in a single operation. The piston-closing pressure shall not exceed the manufacturer's rated working pressure for the operating system. Documentation shall include the manufacturer's shear ram and blowout preventer configurations, the actual pressure and force to shear the pipe. Documentation shall also include pipe description (size, mass and grade), actual pipe tensile properties, and impact properties as specified in ISO 11961. There is the possibility these data could appear in a BSR capability report.

2.1.5 Relevant Requirements from ANSI/API Specification 16c

This API Specification does not appear to have applicable requirements for BSR shear testing. The specification's scope is choke and kill systems.

2.1.6 Relevant Requirements from API Specification 16D

This API Specification does not appear to have applicable requirements for BSR shear testing. The specification's scope is control systems for drilling well control equipment.

2.1.7 Relevant Requirements from ANSI/API Specification 17D

This API Specification does not appear to have applicable requirements for BSR shear testing. The specification's scope is design and operations of subsea production systems.

2.2 Interpretations, Good Practices, and Terminology

The majority of items listed in Section 2.1 from the WCR and proposed WCR are concise and clear. These are must and shall level topics for the verification report. These will be referred to in the balance of this report as either meaning a direct reference to the regulation and/or the terms “shall” or “must” (but not should). Among these requirements several points necessitate interpretation or an opinion as to intent and extent. Examples are:

- Shear testing—“Demonstrates the use of test protocols and analysis that represent recognized engineering practices for ensuring the repeatability and reproducibility of the tests” [§250.732 (b)(1) (ii)],
- Shear testing—“performed by a facility that meets generally accepted quality assurance standards” [§250.732 (b)(1) (ii)],
- Testing—“provides a reasonable representation of field applications” [§250.732 (b)(1)(iii)],

- Pressure integrity testing—“Includes all relevant test results” [§250.732 (b)(2)(iii)]
- “Recognized engineering practices” are applied [§250.732 (b)(3) & (4)], and
- Overall system [...] uses “quality control and assurance mechanisms” [§250.732 (b)(3) &(4)].

Phrases such as “recognized engineering practices,” “generally accepted quality assurance standards,” “reasonable representation of field application,” “relevant test results,” and “quality control and assurance” can have widely varying interpretations. In this report, these examples and similar types of regulatory guidance without a “must” descriptor or specific reference become an opinion or a desirable “good practice” that may or may not be coincident with those of the reader. These terms appear throughout the text of this report.

3.0 General Information

NOTE: THIS SECTION IS THE FIRST SECTION OF AN OUTLINE/FORMAT FOR THE BSR SHEARING VERIFICATION REPORT THAT DEMONSTRATES (FOR REGULATORY PURPOSES) SHEARING CAPABILITY FOR A PARTICULAR COMBINATION OF RIG, WELL, AND BOP STACK. THE VARIOUS SECTIONS AND SUBSECTIONS DESCRIBE CONTENT.

3.1 Rig Identification

At a minimum, provide the unique name of the drilling rig that is the reference of the report.

3.2 Well(s)

Provide the name(s) and lease identification details associated with the well(s) for which the shear ram verification is prepared. This shear report may pertain to several wells, all of which may not be known for the initial submittal of the report. Supplementary documentation or an amendment to this section may associate the drilling rig, drill pipe, and blind shear ram(s) with additional well(s). However, conditions of additional wells should fall within the capability's envelope of the blind shear ram testing.

3.3 HPHT Conditions

Must state when HPHT conditions¹⁴ are anticipated for the wells associated with the report. If they are, Section 6.4 of this document outlines additional reporting requirements and perceived intent of 30 CFR250.732(c).

¹⁴ 30 CFR250.804(b) for HPHT definition (reference provided in proposed WCR).

4.0 Drilling Rig Equipment

4.1 Drilling Rig Shear Ram(s)

Table 1 is a suggested multipurpose format that captures information for the rig shear ram(s) (similar to the tested shear ram in Section 5.2). The table identifies whether the shear ram is actual rig equipment or representative equipment used for shear ram shear capability. When the actual rig equipment is not tested, good practice would be to provide multiple tables to capture comparable information supporting post-test engineering assessments. In addition, the table (and other similar tables) includes consistent quality assurance information which shall meet or exceed the regulatory requirements about quality assurance. Quality assurance information includes at least:

- Quality assurance standard used;
- Quality assurance representative(s);
- Other responsible individuals;
- Individual affiliations and titles/roles; and
- Date(s).

Good practice would be to provide a detailed description of the quality assurance program or a reference to an available document describing the program. The comment column indicates topics that must be provided to support required testing and verification.

Table 1 BOP Shear Ram Configuration Data Sheet

BOP and BOP System Equipment		
Identify whether information in this table pertains to actual rig equipment or representative equipment tested (must) for the reported BSR capability (check one).		
BSR Equipment: <input type="checkbox"/> Actual rig BSR and actuator or <input type="checkbox"/> Representative rig BSR and actuator		
Blowout Preventer (General)	Value and Units	Comments and Notes
Manufacturer		
Description and Type		
Bore Size		
BOP Serial Number (s)		
Blind Shear Ram (BSR)	Value and Units	Comments and Notes
Ram Manufacturer (s)		Report must include
Description and Type (s)		Report must include

Table 1 (Cont.)

BOP and BOP System Equipment		
Centering Feature ¹		Not required to be tested as part of shear capability. Good practice would be to provide technical evidence of this capability possibly based on OEM type testing.
BSR Housing Manufacture Date		
Wellbore Rated Working Pressure (RWP)		Report must include
Wellbore Rated Working Temperature (RWT)		Report must include
Ram Block Part Number(s)		
Ram Serial Number(s)		
Date of Manufacture		
Seal Manufacturer		
Seal Part Number		
Seal Durometer __@ __F		
Seal(s) within Useful Life as Marked?		Yes or No (date of expiration)
Refurbishment and Inspection History		
BOP Blind Shear Ram Actuator	Value and Units	Comments and Notes
Manufacturer		Report must include
Description and Type		Report must include
Main Assembly Number(s)		
Serial Number(s)		
Date of Manufacture		
Rated Working Pressure (Main Actuator(s))		
Other Nameplate Information (e.g., Part Numbers, API Std, etc.)		
Manufacturer's Maximum Specified Shearing Pressure		Report must include
Piston Closing Area		Must include to support MASP correction
Piston Opening Area		Must include to support MASP correction
Piston Rod Area		Must include to support MASP correction
Piston Rod Stroke		Must include to support MASP correction

Table 1 (Cont.)

BOP and BOP System Equipment		
Closing Ratio (Pressure Ratio)		Need to assure the value leading to the highest predicted closing pressure is used.
Booster Information		As applicable
Quality System Used		
Standard/Quality System		Identify Standard, System Implemented, etc.
Last Audit (MDY) ¹		Audit Findings and Certification Period Coverage
Quality Assurance Record Information		
Preparer, Concurrence Name, Date, Affiliation, etc.		Report must include

Table notes: Comments here pertain to report content. The actual BSR shearing verification report should include explanatory information in that space as appropriate. Some topic lines are “good practice” and some reports would add topics for clarity.

Table 2 Shear Test Specimen Data Sheet

Workstring or Tubing or Wireline		
<p>Identify whether the information in this table represents actual rig tubulars/wirelines or representative tubulars/wirelines (check boxes below). Must provide a specimen data sheet for any item sheared and/or referenced in capability determination. Good practice is to include information for each size and type of drill pipe, work string, and tubing to be used in the well and not sheared as part of package verifying shearing capability per 30 CFR 250.700.</p> <p>Type of Tubular or Line: <input type="checkbox"/> Actual rig sample or <input type="checkbox"/> Representative sample Tested (sheared) <input type="checkbox"/> Yes <input type="checkbox"/> No</p>		
Description	Value and Units	Comments and Notes
Tubular Type (e.g., Drill Pipe or Wireline)		Must include
Manufacturer (s)		Must include
Grade or Specification		Must include
Nominal OD (in)		Must include
Nominal ID (in)		Must include

Table 2 (Cont.)

Workstring or Tubing or Wireline		
Weight per ft. (nominal)		Must include
Date of Manufacture		
Source (Specify Rig Name, manufacturer(s), or Other)		
Physical Properties	Value and Units	Comments and Notes
Yield Strength (ksi)		Must include
Tensile Strength (ksi)		Must include
Elongation (%)		
Reduction of Area (%)		
Charpy (ft-lb at _ F)		
Hardness (HRC) and Location (s)		
Chemical Properties	Value and Units	Comments and Notes
Chemistry		
Pipe Material Test Reports		
Quality System Used		
Standard/Quality System		Identify Standard, System Implemented, etc.
Last Audit (MDY) ¹		Audit Findings and Certification Period Coverage
Quality Assurance Record Information		
Preparer, Concurrence Name, Date, Affiliation, etc.		Must include

Table notes: Comments here pertain to report content. The actual BSR shearing report should include explanatory information in that space as appropriate. Some topic lines are “good practice” and some reports would need to add topics for clarity.

4.2 Drilling Rig Shear Ram Support Systems

Desirable support systems for the blind shear ram include hydraulic supply pressure at the entry to the BSR actuator, the type of fluid required, the total volume required to close and shear, and flow rates. The engineering systems analysis should be consistent with this information, and shear testing must reasonably represent anticipated field conditions to the extent practicable.

4.3 Anticipated Well Conditions Pertinent to Shear Ram

4.3.1 General Well Parameters

Anticipated well environmental conditions and ranges of conditions that are important to shear ram performance should be reported. These must include information (to support MASP or other corrections), but are not limited to:

- Location;
- Water depth; and
- Chemistry (hydrocarbons, drilling fluid, acids, H₂S, etc.).

4.3.2 Maximum Anticipated Surface Pressure (MASP) and Other Pressure Corrections

The regulations require that the rig BSR be capable of shearing and sealing the wellbore after shearing under MASP conditions. API Standard 53 has the concept of maximum expected wellbore shear pressure (MEWSP) as the basis for pressure correction relative to shearing capability. This includes adjustments for a closed annular preventer.

Adjustment of shear pressure for MEWSP (or MAST if not most conservative) is mandatory and appropriate for engineering comparisons of shearing requirements to hydraulic supply capabilities. Reported shearing pressure requirements (with appropriate head adjustments) must never exceed the rig's available hydraulic supply pressure. When anticipated shearing actuator pressure exceeds 90 percent of the rig's hydraulic supply pressure, an additional risk assessment must be performed.¹⁵ Good practice would be to include this assessment as part of the engineering analysis and verification of shearing capability and to incorporate statistical variations in the analyses.

4.3.3 Maximum Anticipated Well Pressures and Temperatures

Shear ram performance documentation includes maximum anticipated well pressures and temperatures. If these exceed HPHT thresholds, additional information is required per the regulations (see Section 6.4 of this document.)

¹⁵ API Standard 53 at Section 6.5.10.7.5 uses the term “should” with regard to the risk assessment. In 30 CFR250.198. The meaning of should in a document incorporated by reference is actually must or shall.

5.0 Shear Ram Testing Information

5.1 Testing Facility Details

Facts and details about the testing facility, as listed in Table 3 (or equivalent) need to show adherence to recognized engineering practices and generally accepted quality assurance. Table 3 is a suggested format. Comment entries identify several “must” level topics that are traceable to the regulations.

Table 3 Test Facility Information

Test Facility	Comments/Notes (Attach Additional Pages as Needed)
General Information Required	Enter Information.
Facility Name	Must include
Facility Physical Address	
Test Supervisor Name and Title	Must include (quality assurance)
Client Name and Address	Must include
Client’s Technical POC Name, Title, and Contact Information	
Witnesses (e.g., Third Party, Client, etc.) Name, Title and Contact Information	
Hydraulic System (for Example)	Enter Information.
Pump Nameplate Make, Model, Size, HP, Rating, S/N, etc.	
Regulator Make, Model, Size, S/N, Test Setting (psig), etc.	
Maximum Manufacturer-Rated Working Pressure (psig)	
Maximum Rig Supply Pressure (psig)	
System Configuration (Attach P&ID)	
Test Hydraulic Fluid Product Trade Name and Mixture	
Data Acquisition System¹	Define and Characterize System.
Chart Recorders - Digital Acquisition System Manufacturer(s), Model(s), S/N, Calibrations and Validations	Must include document on current calibration per API Standard 53 (traceable to NIST etc.)
Instrumentation	Define and Characterize System
Closing Pressure, Chamber Pressure Transducer Manufacturer, Model, S/N, etc.	E.g., Maximum Scale (25 – 75% of Full Scale of analog), Accuracy (% of Full Scale), Records of Last Calibration, Measurement Frequency, etc.

Table 3 (Cont.)

Test Facility	Comments/Notes (Attach Additional Pages as Needed)
Opening Pressure, Chamber Pressure, Transducer, and Location on BOP	
Flowmeters	
Backup or Secondary P-Transducers	
Measuring and Examination	Visual inspection is general testing requirement in API Standard 53
Quality System Used	
Standard/Quality System	Identify Standard, System Implemented, etc.
Last Audit (MDY) ¹	Audit Findings and Certification Period Coverage
Quality Assurance Record Information	
Preparer, Concurrence Name, Date, Affiliation, etc.	Must include

¹ Include documentation of the measurement devices and sensors used, date of last calibrations, calibration ranges, etc.

5.2 BSR(s) Tested

Shear ram performance documentation must provide design and operational details about the BSR(s) tested. If the equipment tested is not actual rig BSR (or one of the rig's identical BSR(s)), Table 1 (above) has a dual purpose and can be used to capture the information for either piece of equipment (tested or actual rig BSR(s)). Good practice is to provide tables/information that fully supports post-test engineering capability assessments.

BOP stack traceability shall include information about the quality system and specification of the BSR manufacturer(s). At a minimum good practice would be for tested BOP BSRs manufactured after July 28, 2016, to include API Specification Q1¹⁶ certification by an entity meeting the requirements of ISO 17011 per [30 CFR 250.730 (d)].

5.3 Test Setup

Good practice is for the testing documentation to provide details of the actual shear ram placement in the facility's test setup. Important topics that enable reproducibility and repeatability include:

- Interfaces with facility test system (hydraulic connections, instrumentation, etc.),

¹⁶ ANSI/API Specification Q1 (ANSI/API Spec. Q1), "Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry," Eighth Edition, December 2007, Addendum 1, June 2010 (Incorporated by reference at 250.198).

- Shear ram sensors and transducers and locations (and current calibration certificates),
- Control system,
- Data acquisition system,
- Test specimen support system hardware,
- Test specimen constraints (mechanical apparatus features),
- Test specimen loading (tension or compression or no load),
- Leakage examination (procedure and acceptance criteria),
- Assembly and makeup of the shear ram assembly (photograph, manufacture requirements),
- Piping and instrumentation diagram (P&ID), and
- Position of test specimen in bore.

These subjects must be consistent with the test procedure.

5.4 Test Procedure/Protocol Followed and Acceptance Criteria

The procedure/protocol used for the shear ram must be documented. All steps of the test sequences, including any exceptions, should be listed. Also, good practice includes a written acceptance criteria. Independent of protocol source or reference documentation, this documentation should be a step-by-step description of test procedures beginning with sample preparation and proceeding through ram block and operator function tests, pipe sample positioning, pipe shearing and sealing tests, and inspections. This testing sequence must include consideration of manufacturer requirements.

Good practice on test procedure/test protocol verification by the third party considers:

- Test equipment,
- Test hardware,
- Test procedures,
- Acceptance criteria,
- Facility and personnel qualifications,
- Representation of test facility relative to actual rig and field conditions,
- Shear and seal pressure and temperatures, and
- Data recording/capturing and reporting of test results.

5.5 Test Specimen Selection

Good practice is to document how shear test samples were chosen and prepared and how the samples are typical of the rig tubulars (drill pipe, work string, tubing, electric lines, wirelines, etc.) to be used in the well. This should address metallurgy, design specifications/standards, actual physical and chemical properties, size variations, sample preparation cutting methods, length of test sample, and position in test specimen section. For hot cutting, a heat-affected zone must fall outside the shear test plane on the test specimen and documentation includes technical assurances regarding the extent of any such zones.

5.6 Shear Ram Inspection Information

5.6.1 Pretest Shear Ram Inspection Report

Prior to testing a shear ram, good practice is to conduct and document a full physical inspection of the BSR to be tested (or, at minimum, compliance with manufacturer's requirements). Logically, the scope of the inspection, visual at a minimum, would evaluate condition of:

- Shear blades,
- Ram blocks,
- Wear surfaces of the ram blocks/housing,
- Seal surfaces,
- Elastomers and seals,
- Actuator shaft seals (as applicable),
- Housing (s), and
- Operator(s)/Actuators.

Documentation should identify the applicable manufacturer's specifications and indicate whether the shear ram assembly complies. If modifications or repairs occur during testing or because of testing, the nature and extent of such should also be described. Finally, good practice would be for the third-party certifying entity to verify tested BSR assembly condition.

5.6.2 Post-Test Shear Ram Inspection Report

As outlined in the paragraph 5.6.1, good practice would be a post-test inspection report as part of the shear ram capability verification. This would include a qualified third-party statement that the tested BSR complies with applicable manufacturer's specifications and can be suitable for subsea service (with possible parts replacements) as intended for the well conditions described in Section 3.2.

5.7 Test Results

Table 4 is a possible format to summarize results of each shear test. Test data could be plotted from digital data or recorder charts with notations of key events and visual documentation

supported by actual data files and/or recording charts. (Note: Section 5.8 provides photograph suggestions). Suggested test result content includes:

- BOP shear ram speed and actuator pressures throughout the test (e.g., circular charts or other visual documentation),
- Start/end of shear and subsequent pressure hold test,
- Initial specimen-ram blade contact, and point of shear (actuator pressure),
- Start/end of block travel,
- Indication of whether peak pressure exceeded manufacturer's specification or limitation of the BSR component,
- Pressure test start and end,
- Pressure test history, and
- Hold pressure (duration-5 minutes).

In addition, good practice is to include (or concisely reference) supporting data files or copies of the recorder charts.

Table 4 Shear Test Summary Results

BOP Shear Test Results		
Identify whether the information in this table represents actual rig tubulars/lines or representative tubulars/lines (check one item per line below).		
Test Sample condition or case _____		
Test Sample No. (if more than 1); _____)		
Test Data Summary	Value and Units	Comments/Notes
Date of Shear (MDY and Time of Shear)		Success or Failure per written acceptance criteria?
Opening Pressure (psi)		
Opening Volume (gal)		
Peak Close Pressure (psi)		
Peak Close Volume (gal)		
Peak Shearing Force @ POS ¹ (kips)		

Table 4 (cont.)

BOP Shear Test Results		
Sheared Specimen Description/ID		
Specimen Measured OD (in.)		
Low Pressure Test (psi)		
High Pressure Test (psi)		
Ram Closure Time (sec)		
Upper Specimen, H x W (in.)		
Lower Specimen, H x W (in.)		
Visual Examination ¹		
Quality System Used		
Standard/Quality System		Identify Standard, System Implemented, etc.
Last Audit (MDY) ¹		Audit Findings and Certification Period Coverage
Quality Assurance Record Information		
Preparer, Concurrence Name, Date, Affiliation, etc.		

¹ Visual examination to include photos of test specimen, shear blades, ram packers, and other critical components prior to and after testing and be made part of the report

5.8 Photographic and/or Video Records

The general objective of BSR shear testing and verification documentation should be to capture the testing from setup to post-test assessments, analyses, and inspections. Photographs or videos are valuable to supplement text and narrative and good practice would be to take advantage of such an option. In addition to the examples shown in, Figure 2, and Figure 3, the following paragraphs and Table 5 describe desirable photographic still frame and/or video derived documentation for a BSR shearing report.

5.8.1 Shear Results—Tubulars

Photography of sheared specimens (Figure 2) is a good practice. Such documentation should positively associate information with other tables, charts, and narratives in the BSR shear verification report.

5.8.2 Shear Ram Condition (Before and After) Tests

Photographic documentation of the shear ram cutting and sealing mechanism before and after test shears is good practice. This medium can identify and readily characterize any repairs or alterations between tests. This could also illustrate numerous aspects of supplemental examinations verifying conformance with the manufacturer's specifications.

Table 5 Attributes of Desirable Photographic Documentation

Topic	Documentation Attributes (Could be single frame or part or all could be a video or video monitor screen shots)
Shear Ram Test Support Systems	Blind shear ram test setup including supporting systems and controls as detailed in Table 3. This may require several images, figures, and/or drawings
Shear Ram Ready for Shear Testing	BOP shear ram test setup prior to testing. This may require several images to document.
Tubular Specimen and Specimen Support Apparatus	How the tubulars (listed in Table 2) are supported for the shear tests including any constraint hardware in the bore area. This may require several images, figures, sketches, and/or drawings.
Shear Specimen in Bore of shear Ram Just Prior to Shear Test	Tubulars (listed in Table 2) in the well bore ready to be sheared.
Ram Blocks Before and After Shear and Seal Test(s)	Ram blocks/shear blades before and after shear testing. Logically this includes information about shear cutting edge condition, restoration, or shear blade replacement during the test sequence.
Sheared Tubular	Showing Shape Distortion (before and after, upper and lower)
Shear Ram Seal Assembly	Condition before and after seal testing
Shear Ram Inspection	Verifying that the shear ram assembly complies with manufacturer's specifications particularly before the test. Post-test verification is logical in the interest of safety independent of whether the tested assembly is placed into service after testing.

Figure 1 Example Photographs of Shear Ram Ready for Shear Testing



Visual documentation of the BOP shear ram test setup prior to testing



Above pictures reproduced courtesy of Bastion Technologies, Inc.

Figure 2 Example Photograph of Sheared Tubular Showing Shape Distortion (upper and lower shown)



Reproduced courtesy of Bastion Technologies, Inc.



Reproduced courtesy of Bastion Technologies, Inc.

Figure 3 Example Pictures of Drill Pipe Shears and Shear Test Fixture Used



NOTE: Current Blind Shear Ram cannot cut casing, must use a separate casing share ram (non-sealing)

6-5/8" S135 Drill Pipe Connection (848,600 lbf)



Current super shear rams may cut using 2 mill lbs



6-5/8" S135 Drill Pipe Connection with cement

11-3/4" 60 lb/ft P110 Casing (572,300 lbf)



6.0 Engineering Analyses and Assessments

Sections 3.0 through 5.0 of this report pertain to information about the well, the drilling rig and rig support systems for BOP(s), the specific BOP(s) and BSRs used by the drilling rig, the drill pipe and/or wires used for shear tests, the rig's drill pipe and wires, and shear test results. Within these situations the simplest case in terms of capability assurance is when the rig's actual BSR is used for shear testing with tubular and wire samples from rig stock. In this instance, there are the fewest concerns regarding how representative test results are of actual subsea capability and performance even though certain field conditions are not replicated fully if the tests are done on shore. However, a tested BOP shear ram can be markedly different from a rig BOP BSR as can the tubulars and wires actually sheared. For such situations, there are more technical concerns and uncertainties regarding predicted capability. In addition to the normal adjustments associated with BOP testing in a controlled environment (as compared to a subsea one), good practice is to document a thorough engineering analysis that identifies and characterizes differences between the actual rig BOP and the tested equipment. The goal for either situation (actual hardware or equivalent at some level) or any intermediate circumstance is to verify with high certainty that shearing and sealing can occur and that there is adequate design margin to do so. The following sections describe good practice for such engineering comparisons and analyses.

6.1 Theoretical Shear Calculations

A comparison of current test results to historical experiences is useful to address issues such as whether the rig BOP support system has adequate supply pressure to shear all tubulars and the statistical certainty of doing so.

There are numerous engineering methods and formulas for predicting shear force for a given tubular and shear ram combination. Some methods are based on mechanics fundamentals, while others may be empirical (such as a correlation with data collected). Independent of the basis, good practice documentation should provide formula(s), values for constants, definitions of variables and associated units, narrative about whether a particular formula is derived for the particular design being evaluated, whether the formula results represents the average, mean, median, or some other measure of supporting data, and assumptions. Good practice for any formula or mechanics model is to present validation information to support quantification of uncertainties. Further, good practice for either formula or predictive method(s) is to provide references sufficient to enable BSEE personnel (based on the reference) to request and inspect the validation information and protect intellectual property when needed. This is one part of documentation that helps ensure test repeatability with similar results.

6.2 Shear Ram Support Systems Capability Assessment

Ideally the hydraulic system for BSR shear testing should resemble field conditions and capabilities to the extent practicable. Key technical considerations are:

- Hydraulic fluid type,
- Supply pressures and pump flow rate at BSR manifold,
- Fluid temperature,

- Elastomer materials, and
- Volume of fluid available.

The capabilities verification documentation should include a technical assessment of field versus test differences and impacts of the differences on performance of the actual subsea BOP shear ram. Presumably, the test system provides comparable pressures and flows to those of the offshore systems.

6.3 Certainties Assessment

6.3.1 Expected Variation in Test and Calculated Shear Pressures

Since any shear test pressure can be higher or lower than anticipated and since possible variance is large when sample size is small, the relative certainty of test results is important. Further a statistically significant number of shear tests is unlikely to support shear performance because of the time and cost. The next best option, good practice, is to compare calculations and data and consider expected variances of that information. In so doing, a conservative operating margin can be determined for the shear ram support systems.

6.3.2 Comparisons of Rig Versus Tested Equipment

A shear and seal test performed at an onshore test facility (e.g., OEM test facility) can never exactly duplicate field conditions (even if the rig's BOP and test specimen were used in the test at the onshore facility). Thus, a documented systems engineering assessment is good practice to identify and evaluate substantial technical differences and similarities. Arguably such assessments bridge the gap between an onshore test and a BSR connected to different systems offshore. Performance considerations are:

- Adjustments to required shearing pressures (heads, mechanical losses, MASP, MEWSP, appropriate to service conditions);
- Hydraulic fluid type and characteristics, including viscosity and thermal stability. Comparative assessments must include a risk assessment if shear pressure exceeds 90 percent of system capability;¹⁷
- Physical, mechanical, and chemical pipe properties prior to shearing.¹⁸ In addition to the physical and mechanical properties (e.g., the wall thickness (in.), hardness (HRC), and outside diameter (in.));
 - o Physical properties of sealing elastomers and temperature variations. The shear and seal tests may be conducted at 70°F, but actual well conditions could vary from near freezing to 300°F or more; and

¹⁷ See API Standard 53 (November 2012), at Sections 6.5.10.7.5.

¹⁸ 30 CFR §250.732 (b)(1)(v)

- o Issues of chemical compatibility and performance of the sealing elastomer with the anticipated fluids that may be present in the well versus the elastomer seal material used for BSR shear testing.

6.4 HPHT Specific Requirements

The Verification Test Report (the shear document accompanying the well application, including clearly referenced supplements or addenda) must per regulation contain additional information if the BOP stack is expected to experience HPHT environment. Certain verifications must be documented and submitted before beginning HPHT operations.¹⁹ Key HPHT BSR shear test requirements are²⁰:

- “Verification that the BOP equipment will perform as designed in the temperature, pressure, and environment that will be encountered”
- “Verification that the fabrication, manufacture, and assembly of individual components and the overall system uses recognized engineering practices and quality control and assurance mechanisms” including “For the quality control and assurance mechanisms, complete material and quality controls over all contractors, subcontractors, distributors, and suppliers at every stage in the fabrication, manufacture, and assembly process.”

¹⁹ See 30 CFR §250.732 (c)

²⁰ [§250.732 (b)(3) &(4)]

7.0 Statement on Shear Ram and System Fitness for Service

This section outlines a desirable summary and conclusion of the testing and engineering analyses conducted for the proposed BSR-well combination. The third-party verifier must be a signatory per 30 CFR **250.732**.

7.1 Shear Ram

Specifically state and attest that the rig BSR capability, as configured in the BOP system on the actual rig, is adequate to shear any and all rig tubulars and wires as stipulated in the regulations.

7.2 Support System

Specifically state and attest that the BOP support system on the rig is adequate to assure required performance of the subsea shear ram. Local supply pressure is a key consideration, but other technical issues should also be addressed if there is an expected limitation or constraint.

7.3 Caveats and Limitations

List any and all caveats and limitations associated with the statements on shear ram performance, associated support systems, and overall fitness for service. This would include any operational or compatibility areas found in the assessments (based on testing and engineering considerations) to perform at the proposed location.

8.0 References for Shear Reporting

Good practice is to list all references cited in the capabilities verification report. The reference description information should be complete enough that BSEE can acquire the information readily. Any proprietary information should be clearly marked and noted.

Appendices

A: Quality Assurance Program(s)

Testing Activities

Provide summary of QA program or reference program documentation. Topics include:

- Facility test equipment,
- Data recording equipment,
- Procedures,
- Protocol process,
- Audits,
- Responsible personnel, and
- Quality related documentation.

If equipment is manufactured after effective date of WCR (July 28, 2016) API Spec Q1, Eighth edition equivalent as a minimum is applicable (officially incorporated by reference at 30 CFR 250.198) or later edition, based on justification per regulations. Also, complete documentation identifies competent third-party principals performing, reviewing, and approving the report content along with their organizational affiliation and dates.

Engineering Analyses

Provide summary of QA program or reference program documentation. Topics include:

- Procedures,
- Peer reviews,
- Third-party review,
- Audits,
- Responsible personnel, and
- Quality documentation.

Use API Spec Q1, 8th edition equivalent as a minimum or a later edition if officially incorporated by reference at 30 CFR 250.198). Also document the competent third-party principals performing, reviewing, and approving the report content along with their organizational affiliation and dates.

B: Personnel Qualification and Credentials

Third-Party Professional and Engineering Qualifications/Registrations

Other Pertinent Qualifications

C: Miscellaneous Information

Manufacturer's Specifications

Test Procedures

Tubular and Wire Chemistry

Tubular and Wire Physical Property Reports

Pre- and Post-Test Inspection Reports

Raw Shear Test Data or Recording Charts

D: Cross Tabulation of Major Requirements to Paragraphs

The following table provides correlation of paragraphs in this report with the major requirements appearing in Section 0 of this report. Requirement numbers coincide with the numbers appearing in that listing.

Table D-1 BSR Shearing Report Requirements, Topics, and Sections Addressing Those Topics

Req #	Requirement Topic	Paragraph(s) Relevant to Requirement	Comments/Notes
WCR and Proposed WCR Requirements			
1	API 53 Eighth edition, "Blowout Prevention Equipment Systems for Drilling Wells" in CFR	Responses to Requirements 9-18 below	If conflict follow 30 CFR. 30 CFR requires shear testing rather than just predictive calculation or shear testing.
2a	ANSI/API Spec. 6A, "Specification for Wellhead and Christmas Tree Equipment" in CFR		No BSR Shear test requirements identified
2b	ANSI/API Spec. 16A, "Specification for Drill-through Equipment" in CFR		No BSR Shear test requirements identified
2c	ANSI/API Spec. 16C, "Specification for Choke and Kill Systems" in CFR		No BSR Shear test requirements identified
2d	API Spec. 16D, "Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment" in CFR		No BSR Shear test requirements identified
2e	ANSI/API Spec. 17D, "Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment" in CFR		No BSR Shear test requirements identified
3	Independent Third-Party Verification	Sections 5.4, 5.6, and 7.0. Appendices A and B	
4a	Testing demonstrates shear any pipe and wire in bore	Section 4.1, 4.2, 4.3, 4.4, 5.0, 6.0, and 7.1.	

Table D-1 (Cont.)

Req #	Requirement Topic	Paragraph(s) Relevant to Requirement	Comments/Notes
WCR and Proposed WCR Requirements			
4b	Test protocols used based on recognized engineering practices for repeatability and reproducibility with quality control in facility	Sections 5.1 and 5.4. Appendices A and C	
4c	Reasonable representation of field conditions	Sections 3.0, 4.1, 4.2, 4.3, 4.4, 5.3, 6.2, 6.3, and 7.0. Appendix C	
4d	Edge of blade shear testing	Sections 4.1, 4.3, and 5.2. Appendix C	
4e	Shearing capability demonstration to pipe properties	Sections 4.2, 6.0, and 7.0. Appendix C	
4f	Relevant test results	Section 5.7 and 5.8. Appendices A and C	
5a	Pressure integrity immediately after shear test	Section 5.7 and 7.1.	
5b	BSR shears at RWP for 5 minutes	Section 5.7 and 7.1. Appendix C.	
5c	Includes all relevant test results	Section 5.7. Appendix C.	
6	MASP calculations for all shearing and sealing pressures to be used in well	Section 2.1, 3.0, 4.1 4.4, and 6.0	
7a	HPHT-performance in environment	Section 3.3.	
7b	HPHT-manufacturing with quality assurance	Sections 3.3, 4.1, and 4.2.	
8	Capable of shearing at any point along tubular body	Sections 6.0, 7.0, and 7.1.	
API Standard 53 Requirements			
9	MASP Defined	Sections 3.0 and 4.4.2.	
10	Part of testing is visual inspection	Section 5.6 and 5.8.2. Appendix C	
11	Annual calibration of test pressure measurement devices	Section 5.1 and 5.3. Appendix C	
12	Calibrations traceable to NIST	Section 5.1 and 5.3. Appendix C	
13	Surface BOP rod seals check	Section 5.6. Appendix C	

Table D-1 (Cont.)

Req #	Requirement Topic	Paragraph(s) Relevant to Requirement	Comments/Notes
WCR and Proposed WCR Requirements			
14	Shear with effects of closed annual preventer	Section 7.0.	
15	Risk assessment when shear pressure 90% or more of available rig supply pressure	Sections 6.2 and 6.3.	
16	Manufacturer to verify shearing capability for planned drill pipe	Sections 3.0, 4.1, and 4.2.	
17	Actual BSR shear testing required	Section 4.1 and 4.2. Appendix C	
18	Capability verification by competent provider.	Appendix B	



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